PATENT SPECIFICATION 893,074

DRAWINGS ATTACHED.

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COMPLETE SPECIFICATION.

Hydrostatic Drive.

We, PATRA, PATENT-TREUHAND-ANSTALT, a Body Corporate organised under Liechtenstein law, of Schaan, Principality of Liechtenstein, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a hydrostatic drive comprising hydraulic pressure pumps and hydraulic motors.

It is already known to provide pumps, the rotors of which are coupled to be effective as flow dividers, between such hydraulic pressure pumps and motors, which pumps differ in size when the hydraulic motors differ in power output. The flow divider pumps consist of gear pumps, which are coupled by a mechanical connection, the gears of the several pumps being arranged on continuous shafts. To provide for different sizes of the pumps the housings which take up the gear trains are of different size. It has also been proposed to use equal housings and to provide for a variation of the width of mesh of gears for adaptation to the different power output of the hydraulic motors. Such differences occur, e.g., in vehicles having front- and rear-axle drives. In these vehicles the adhesive weights on the two axles are different. For this reason the danger exists that wheels which are under a lower weight will run free, which has the disadvantage that the input capacity of the hydraulic motors which drive these free-running wheels becomes greater than that of the hydraulic motors driving the other wheels so that the latter receive less pressure liquid or do not receive any pressure liquid at all. In this case coupled flow dividers disposed in the supply conduits to these hydraulic motors prevent the wheels from running free. On the contrary, the occurrence of a lower or even extremely low torque in the hydraulic motors driving the free-running wheels causes the flow dividers associated with these hydraulic motors to act as motors, which thus ensure an increased supply of pressure liquid under increased pressure to the hydraulic motors driving the wheels which require a higher driving torque because they are under a higher weight.

The present invention is based on the further recognition that in such vehicles, as in all hydraulic drives, operating conditions may arise in which the measures mentioned hereinbefore are not sufficient. For instance, when a vehicle is moving through a curve, and the centre of gravity of the vehicle has an angular velocity around the centre of curvature, those wheels which are remote from the centre of curvature will have a higher peripheral velocity than the wheels which are nearer to the centre of curvature of the curve. For this reason the hydraulic motors driving the outer wheels require a larger quantity of liquid than the hydraulic motors driving the nearer wheels unless some wheels slip or run free. This is of special importance in a multi-wheel drive of heavy trucks. Other applications are found, e.g., in hydraulic drives for cranes. In the latter case, e.g., an increasing displacement of the centre of gravity of the jib arm from the centre of rotation of the crane requires a displacement of the counterweight in the opposite direction to prevent a tilting of the crane. There is a definite relation between the two parameters con-

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sisting of the displacements of the centres of gravity of the jib arm and of the counterweight. This provides for a functionality which must be taken into account if the pivotal movement of the jib arm and the movement of the counterweight are effected by a hydraulic drive and the stability of the crane should be maintained unchanged, as has been set hereinbefore. Another problem of this kind is found in a vehicle which has propulsion means effective in water and on land consisting of screw propellers and wheels or chains, and a capstan for moving the vehicle if the other two propulsion means fail, or for assisting them. A fixed point must be provided, of course, to which the end of the rope wound up on the capstan is fixed. In this case the problem is to prevent interference between the three drive means when all are hydraulically driven at the same time and to cause them to assist each other, e.g., during a landing of the vehicle, by feeding the wheels of the wheel-driving hydraulic motors increasingly with those quantities of pressure liquid which correspond to the increasing torques which are due to the increasing coefficient of friction and loads at the periphery of the wheels whereas, on the other hand, the decreasing load on the screw propeller is to be taken into account by feeding less pressure liquid to the liquid motor which drives the screw propeller. Similar problems are encountered in the operation of excavators, etc.

Thus, according to the present invention we provide a flow divider for a hydraulic power transmission system comprising a pump device having at least two inlets and a common supply conduit thereto which device serves to divide such supply into a similar number of outlets for respective hydraulic motors, and externally adjustable means which in operation act directly on said pump device and serve to regulate the ratio of the amounts of liquid which, in operation, are delivered to each outlet, this ratio being substantially constant for each setting of the said adjustable means.

A flow divider according to the invention can thus be automatically adjusted in accordance with a given characteristic or functionality by the use of means which introduce this functionality or characteristic into the flow divider. This functionality is most simple in the above-mentioned case of a vehicle going through a curve without slippage and free-running of the wheels because the amounts of liquid consumed by the hydraulic motors increase linearly with the increase in the radius of curvature if the liquid pressure remains constant, the reference quantity being that which is consumed when driving straight ahead. In accordance with this simple functionality the mechanical means for introducing it into the control are extremely simple. As will be described hereinafter, it is sufficient to provide the setting means for varying the quantities of liquid to be handled by the flow dividers with setting levers of different lengths acting on the different pumps and to provide an adjusting member which connects the levers to vary the liquid quantities handled by the flow dividers in proportion with the lengths of the levers. If the adjustment of the flow divider is to be in accordance with a more complicated functionality than the linear functionality just described, this can be achieved by the use of suitable known mechanical gear-boxes, or electrical controls or gear-boxes, with the help of which a suitable control of the flow dividers can be effected.

It is not always suitable to couple the flow dividers in all conduits leading to the hydraulic motors. For instance, in motors which drive a screw propeller, vehicle wheels or chains and a capstan, a common flow divider will be associated with the hydraulic motors which drive the capstan and the vehicle wheels. This flow divider will only be coupled to the flow divider which is disposed in the conduit to the hydraulic motor which drives the screw propeller. Thus, provision is made for the conditions which exist during the landing of vehicles. A second group of flow dividers, which are coupled to each other, lies in the conduits to the hydraulic motors which drive the wheels so that the free running of a single wheel is prevented if the adhesion at the periphery thereof differs from that of the other wheels.

Such flow dividers may be designed in various forms. It is particularly suitable to construct them as sliding-vane pumps, preferably as relieved sliding-vane pumps. Relieved sliding-vane pumps have the special advantage that the forces acting on the rotor as well as the forces acting on the bearings are balanced except for small components, so that small adjusting forces are required. This is of advantage to the construction of the adjusting gear. The adjustment of the rotor of such sliding-vane pumps or relieved sliding-vane pumps which act as flow dividers is suitably effected by means of eccentrics consisting preferably of eccentric rings, sleeves or discs. If the eccentrics are controlled by an adjusting gear which applies a controlling variable introduced into the gear to the several eccentrics in accordance with the functionality to be established, the relation between the quantities of liquid handled by the flow dividers will vary in accordance with this functionality. If the amounts of pressure liquid to be handled are linearly proportional this may be achieved in a simple

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carries the rotor 37 is eccentrically mounted in the manner shown in Figures 1 and 2. The adjustable eccentric is indicated at 43. Owing to the balancing of the forces acting on the rotor 37 and a corresponding reduction of all adjusting forces the means which serve for adjusting the eccentric can be extremely small and the adjusting gear for adjusting the eccentricity is of correspondingly light weight. The pressure liquid is supplied from a feed pump to the working spaces 39, 40 through the connections 44, 45 and is discharged through the connections 46 and 47. The connections 44 and 45 suitably merge to form a common supply conduit (not shown). Conduits (not shown) are provided to extend from the connections 46, 47 to the liquid motors to be controlled. If s_1 is the upper gap shown in Fig. 3 and S the largest gap in the working space 39 and if it is assumed that $S=2\ s_1$ and if s_2 is the lower gap between the rotor 37 and the housing wall 36, the quantity of pressure liquid discharged through the connection 46 will be less than the quantity which is discharged through the connection 47 if s_1 is less than s_2. In the position shown in Fig. 3 $s_1=s_2$ and the eccentricity is at right angles to the plane connecting the gaps so that an annular cylindrical body of liquid having the thickness s_1 or s_2 will always revolve with the rotor, running in the clockwise sense 48. If s_1 becomes less than s_2 the thickness of this revolving annular cylindrical body will be reduced. On the other hand, the increase of the gap s_2 will cause more pressure liquid to flow from the working space 40 into the working space 39 than in the position of Fig. 3 so that the quantity of pressure liquid discharged at 46 is reduced, which reduction has been anticipated. If $s_1=0$, the quantity of liquid discharged at 46 will also be zero because then $s_2=S$. This means that only that law is effective according to which the pressure liquid follows the path of least resistance. This resistance is larger at 46, where a hydraulic motor is connected, than in the gap s_2. For this reason the quantities handled can be regulated between a minimum and a maximum in the same manner as with the means of Figs. 1 and 2 with the advantage that the rotor bearings and adjusting means are highly stress-relieved.

Fig. 4 shows the use of a flow divider according to Fig. 3 in a motor vehicle to ensure that its driving wheels will go through any curve without slipping or running free.

The frame of the motor vehicle is shown diagrammatically at 49. 50 shows the drive motor for the pump 51, which pressurizes the working liquid. The steering wheel of the vehicle is indicated at 52, the steering wheel shaft at 53, the steering worm at 54, the steering worm sector at 55, the steering arm at 56 and the track rod at 57. The stub axles are indicated at 58 and the front wheels of the vehicle at 59. The rear wheels 60 are driven by hydraulic motors 61. Because these hydraulic motors have a different input capacity for pressure liquid under equal pressure when the vehicle is going through a curve, the invention provides a flow divider 62 which is constructed in accordance with Fig. 3 and which automatically effects the necessary distribution of quantities in dependence on the steering of the vehicle. Because only a single rotor 63 is provided, a single lever 64, which corresponds to the levers 24, 25, 26, etc. of Fig. 1 is sufficient for adjusting the eccentric as required. For this the lever 64 is linked by the push rod 65 to the steering arm 56. The feed pump 51 delivers pressure liquid through a conduit 66 and a branch conduit 67 to the flow divider 62. The quantities of liquid discharged by the flow divider 62 through conduits 68, 69, which correspond to the connections 46, 47 in Fig. 3, are fed to the driving hydraulic motors 61 in such a manner that the driving motor for the left-hand rear wheel will receive more pressure liquid than the driving motor for the right-hand rear wheel when the vehicle is going through a curve to the right, the quantity of liquid discharged by the flow divider 62 to the left-hand motor being increased and that to the right-hand motor being decreased in linear proportion with that required for driving straight ahead so that both wheels roll along the curved paths prescribed by the steering linkage without slipping and running free.

The supply conduits for the pressure liquid are shown with dash lines. Return conduits 70, 71 accommodate throttle valves 72, 73, which are operable by a handle 74 so that braking torques for braking the vehicle can be exerted on the liquid motors 61. To prevent an inadmissibly high rise of pressure, measuring instruments 75, 76 are connected by measuring conduits 77, 78. Over-pressure relief valves 79, 80 are also provided for an automatic relief of excessive pressures. The conduits 70, 71 merge at 81 so that the liquid can flow through a cooling device 82, in which the pressure liquid is cooled. This may be assisted by the relative wind or a fan. The cooled liquid is delivered into a reservoir 83, from which the supply pump 51 can draw fresh working liquid through conduit 84.

WHAT WE CLAIM IS:—

1. A flow divider for a hydraulic power transmission system comprising a pump device having at least two inlets and a common supply conduit thereto which device serves to divide such supply into a similar number of outlets for respective hydraulic

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manner by providing the member which introduces the controlling variable into the gear, e.g., a push rod, with adjusting levers pivoted thereto, the lengths of which are in the same proportion as the amounts of liquid to be handled by the several flow dividers. In the case of the vehicle drive first mentioned hereinbefore this means that the eccentrics are preferably given external teeth in mesh with toothed wheels, the shafts of which are controlled through the intermediary of said adjusting levers by a push rod. This push rod is connected to the steering gear of the vehicle so that the steering deflection of the vehicle corresponds to the controlling variable which is to be introduced into the adjusting gear consisting of the push rod, levers of different length, toothed wheel shafts, toothed wheels and the toothed eccentric.

To enable a variation of the quantities handled relieved sliding-vane pumps will be constructed to leave gaps at the points where the rotor is closest to the housing. The width of each gap is preferably chosen to be half the maximum eccentricity to which the eccentric can be adjusted when the eccentricity is at right angles to the plane which connects the gaps.

The accompanying drawings illustrate embodiments of the invention by way of example.

Fig. 1 is a vertical cross-sectional view on line I—I of Fig. 2 showing three flow dividers which are constructed according to the invention disposed one beside the other.

Fig. 2 corresponds to a horizontal sectional view taken on line II—II of Fig. 1.

Fig. 3 illustrates a flow divider constructed in the form of a relieved sliding-vane pump in a diagrammatic cross-sectional view of such a pump.

Fig. 4 shows the general arrangement for a vehicle drive.

Figs. 1 and 2, show a housing which accommodates three flow dividers and comprises three housing plates 1, 2, 3. The housing plates 2 and 3 define cylindrical openings 4, 5, 6 in which rotors which will be described hereinafter are accommodated. Connections 7, 8 for pressure liquid supply to two of the rotors and a connection (not shown) for the pressure liquid supply to the third rotor, which is accommodated in the opening 6, are combined at 9 and 10 to form a common pressure liquid supply conduit 11. Water, oil, oil emulsions, glycerine, mercury and synthetic substances may be used as pressure liquids; this listing is not exhaustive. The quantities of pressure liquid handled by the flow dividers are discharged through connections 12, 13 and a connection (not shown) in the housing plate 1, this latter connection being associated with the opening 6, and then flow in conduits (not shown) to three hydraulic motors each of which is connected to one of the connections 12, 13, and the connections from the opening 6.

It is apparent in the centre of Fig. 1 that the rotors 14 are constructed as sliding-vane pumps provided with vanes 15 and accommodated in sleeves 16, which also contain the bearings for the rotors. The bearings comprise ball bearings 18 lying in eccentric rings 19 and shrunk on the shafts 17 of the rotors. The rings 19 have teeth 20 in mesh with toothed wheels 21, which are carried by adjusting shafts 22. The adjusting shafts 22 are mounted in bearings formed by the housing plates 1, 2. At their ends extending through one end 23 of the housing the toothed wheel shafts 22 carry adjusting levers 24, 25, 26, etc. of graded lengths. A common push rod, which is indicated only by its centre line 27, introduces a controlling variable into the flow dividers. This movement is transmitted to the eccentric rings 19 and to the rotors 14 with the characteristic determined by the length ratios of the levers 24, 25, 26, etc. If the eccentricity of a rotor is exactly adjusted to the value at which the crescent-shaped working space 28 between the rotor 14 and its holding means 29 has the shape of a cylindrical ring, this flow divider will not handle any pressure liquid because no forces can become effective which would compel it to rotate and discharge pressure liquid. This is changed when the rotor is adjusted to define a crescent-shaped working space. The quantity of liquid which is handled will reach a maximum if a rotor 14 and the holding means 29 contact along a line. Because the rotors in all openings 4, 5, 6, etc., are inter-coupled by toothed wheels 30, 31, etc. keyed on their shafts 17, via idler wheels 32, the shafts 33 of which are rotatably mounted at 34 in the housing plates 2, 3, the rotor having an annular working space will be driven by the other rotors unless all rotors 14 thus coupled are in a central position. Thus, these other rotors serve as motors driving the rotor which is then acting as a pump. Because the lengths of the levers 24, 25, 26, etc. determine the proportion of the amounts of liquid handled, the hydraulic motors connected at 12, 13, etc. can be influenced as desired.

Fig. 3 shows the construction of a flow divider which is constructed as a relieved sliding-vane pump. A housing 35 here confines a space 36 of oval cross-section, in which a rotor 37 having the vanes 38 rotates. Because crescent-shaped working spaces 39, 40 exist now on both sides of the rotor 37, the forces acting on the rotor 37 are balanced with respect to the axis of symmetry 41 of the rotor. The shaft 42 which

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motors, and externally adjustable means which in operation act directly on said pump device and serve to regulate the ratio of the amounts of liquid which, in operation, are delivered to each outlet, this ratio being substantially constant for each setting of the said adjustable means.

2. A flow divider as claimed in Claim 1 in which the said pump device comprises at least two sliding-vane pumps having inter-connected rotors.

3. A flow divider as claimed in Claim 1 in which the said pump device comprises a relieved sliding vane pump.

4. A flow divider as claimed in Claim 2 or 3 in which the externally adjustable means are adjustable eccentrics in which the rotors of the sliding-vane pump(s) are mounted.

5. A flow divider as claimed in Claim 4 in which the said eccentrics are eccentric rings, sleeves or discs.

6. A flow divider as claimed in Claim 3 and 4 or 5 in which the housing and the rotor of the said pump define gaps of predetermined width where they are closest together, the said gaps being equal if the eccentricity is at right angles to the plane which connects the gaps.

7. A flow divider as claimed in any of the preceding claims together with means for automatically operating the externally adjustable means.

8. A flow divider as claimed in Claim 7 in which the means for automatically varying the adjustable means are constructed to effect the variation in accordance with a known characteristic.

9. A flow divider as claimed in Claim 4 and 8 in which the said means for automatically operating the adjustable means comprises a push rod having adjusting levers connected thereto and to the said eccentrics.

10. A flow divider as claimed in Claim 9 in which the eccentrics are provided with teeth in mesh with toothed wheels on shafts to be turned by the said levers.

11. A flow divider as claimed in Claims 9 and 10 in which the said push rod is connected to a moving part of the steering mechanism of a vehicle to regulate the amounts of liquid fed to hydraulic motors driving wheels on opposite sides of the vehicle when cornering.

12. Flow dividers substantially as herein described with reference to the accompanying drawings.

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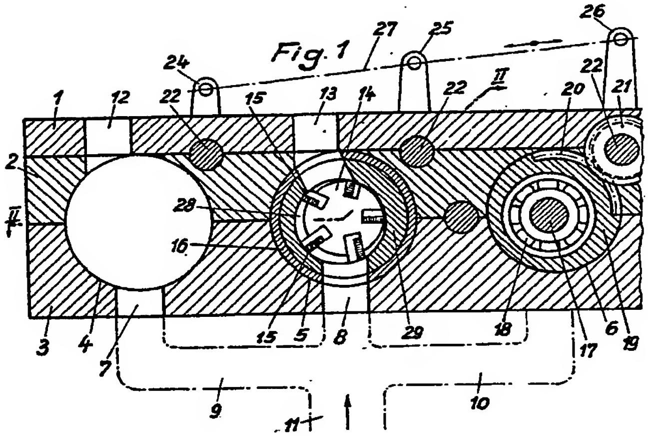
893074 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1



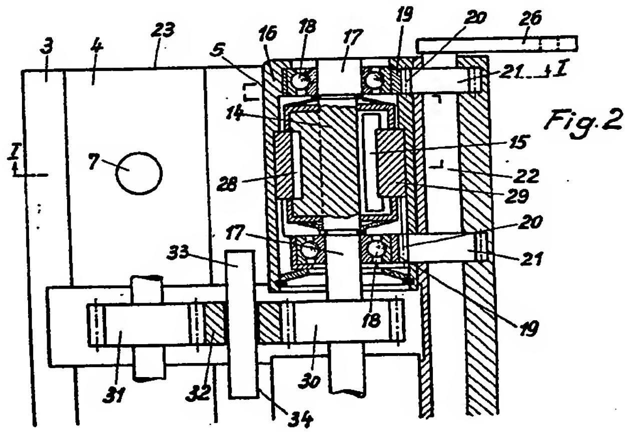


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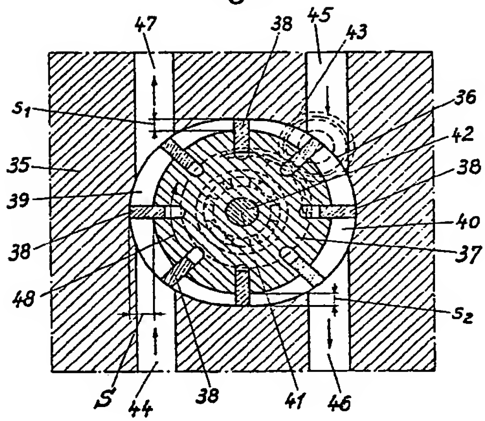
Fig. 3



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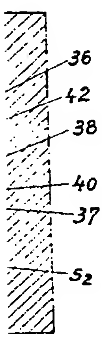

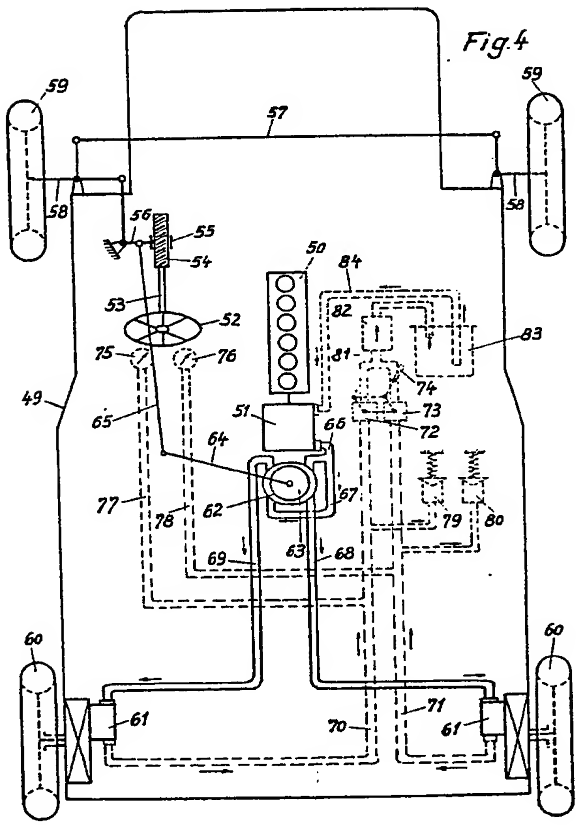

Fig.4

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Fig. 3

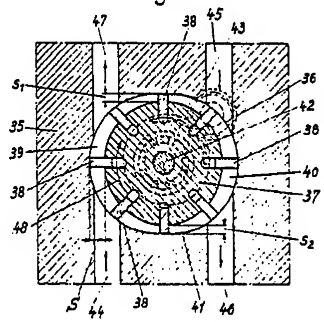
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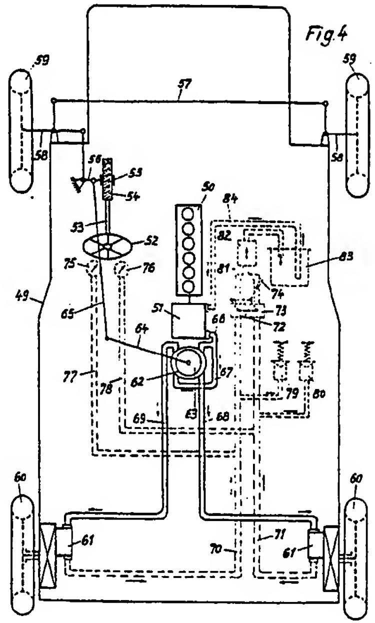
Fig. 4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